Limiting Peak Base-Shear and Displacement In Extreme Seismic Events Using Sacrificial Fuses and High-Capacity Viscous Damping

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ABSTRACT:

Viscous damping can be used to limit structural response due to seismic excitation. However, if large response velocities occur during an extreme seismic event such as a Maximum Considered Event (MCE), then significant damping forces can be created due to the damper velocity dependence. These damping forces are important as they must be resisted by the foundation, increasing design demand. Therefore, methods to predict and limit peak damping forces are important. To avoid the possibility of large foundation demands a yielding fuse can be used in series with the viscous damper to enable incorporation of large capacity viscous dampers to dissipate large amounts of energy during lower-level seismic events without inducing unacceptably high foundation demands during larger events.

This paper delineates the impact of this approach in a probabilistic spectral design analysis using a suite of probabilistically scaled seismic events and a nonlinear model. Reduction factors versus a linear system with the same damper are calculated for base shear and displacement.

A reduced sacrificial fuse yield force of 25% of the median base-shear force of the uncontrolled structure has only a small impact on displacement response, but can significantly reduce peak base-shear during extreme seismic events. The 95th percentile displacement reduction factors increase from 0.85 to 0.96 (small displacement reductions) but 95th percentile base-shear reduction factors decrease from 2.0 to 1.4, which is a significant reduction in peak foundation demand.

This analysis clearly outlines the design tradeoffs and considerations for realistic structural design scenarios using added viscous damping.